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 TI Adamite rolls with high wear and surface roughening resistance for hot rolling of steels  
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AB In the adamite roll, the outer material comprises a Fe alloy containing C 1.0-2.5, Si 0.2-2.0, Mn 0.2-2.0, Ni 0.2-3.0, Cr 0.5-4.0, Mo 0.2-2.0, B 0.001-0.50, Al 0.001-0.50, Ti 0.001-0.50, Zr 0.001-0.50, Cu 0.001-0.50, Mg 0.001-0.50, and Ca 0.001-0.50 weight%, optionally with W 0.2-3.0, V 0.2-3.0, Nb 0.2-3.0, and/or Co 0.2-3.0 weight%. Since the Fe alloy has a microstructure containing uniform and fine spherical grains of M3C eutectic carbide, the adamite roll has high wear resistance and surface roughening resistance.

# PATENT ABSTRACTS OF JAPAN

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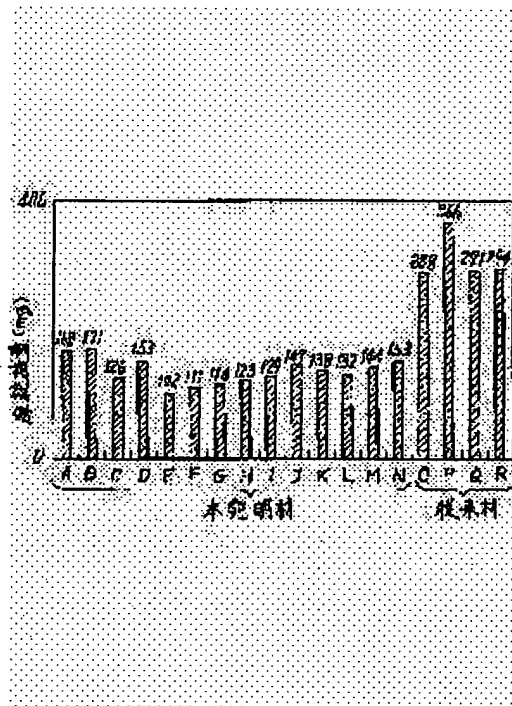
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## (54) ADAMITE ROLL FOR HOT ROLLING

### (57)Abstract:

PROBLEM TO BE SOLVED: To provide an adamite roll for hot rolling, which has both skin irritation resistance and wear resistance.

SOLUTION: The adamite roll for hot rolling comprises an outer layer material including 1.0-2.5% C, 0.2-2.0% Si, 0.2-2.0% Mn, 0.2-3.0% Ni, 0.5-4.0% Cr, 0.2-2.0% Mo, 0.001-0.50% B, 0.001-0.50% Al, 0.001-0.50% Ti, 0.001-0.50% Zr, 0.001-0.50% Cu, 0.001-0.50% Mg, and 0.001-0.50% Ca, by mass%, and Fe and unavoidable impurities as remainders.



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**CLAIMS**

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[Claim(s)]

[Claim 1] By mass %, C:1.0 - 2.5%, Si:0.2-2.0%, Mn:0.2-2.0%, nickel: 0.2-3.0%, Cr:0.5-4.0%, Mo:0.2-2.0%, B:0.001 - 0.50%, aluminum:0.001-0.50%, Ti:0.001-0.50%, Zr: The adamite roll for hot rolling which consists of outer layer material which contains 0.001-0.50%, Cu:0.001-0.50%, Mg:0.001-0.50%, and calcium:0.001-0.50%, and consists of the remainder Fe and an unescapable impurity.

[Claim 2] as outer layer material -- further -- mass % -- one sort or the adamite roll for hot rolling according to claim 1 contained two or more sorts of W:0.2 - 3.0%, V:0.2 - 3.0%, Nb:0.2-3.0%, and Co:0.2 - 3.0%\*\*.

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DETAILED DESCRIPTION

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## [Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention is used for hot rolling of the die steel of steel, sheet metal, a thick plate, etc., and relates to the adamite roll for hot rolling which was especially excellent in abrasion resistance and surface deterioration-proof nature.

[0002]

[Description of the Prior Art] In recent years, in the hot rolling fields, such as steel, for example, die steel, sheet metal, and a thick plate, the demand of upgrading of a flat rolled product is high, and high abrasion resistance and surface deterioration-proof nature are called for also from the roll for rolling. It is indicated by JP,62-18241,B as outer layer material of the adamite roll for rolling corresponding to these demands. To the adamite material which is low alloy high carbon steel-casting material known from the former, these technical contents tend to add Ti, Zr, etc. in a minute amount, tend to make homogeneity and detailed the M3 C eutectic carbide which consists in the perimeter of a matrix in a matrix, and, as a result, tend to raise the abrasion resistance of a reduction roll, and surface deterioration-proof nature.

[0003]

[Problem(s) to be Solved by the Invention] however, with said conventional roll for rolling By the homogeneity and detailed-ization of the M3 C eutectic carbide which consists in the perimeter of a matrix Although the abrasion resistance of a reduction roll and surface deterioration-proof nature improve considerably, in order to correspond to the present severe rolling operation, i.e., a high speed, a heavy load, a large draft, etc. In the point of the abrasion resistance of a reduction roll, and surface deterioration-proof nature, the expectation by users, such as improvement in a roll material unit and simplification of the maintenance service of a roll, is still great not sufficient thing but the result. This invention aims at what the M3 C eutectic carbide which consists in the perimeter of a matrix tends to be made to make it homogeneity and detailed further, consequently it is going to raise sharply the abrasion resistance of a reduction roll, and surface deterioration-proof nature for in view of the above background.

[0004]

[Means for Solving the Problem] The place which this invention is what solved the problem mentioned above, and is made into the summary of the invention (1) By mass %, C:1.0 - 2.5%, Si:0.2-2.0%, Mn: 0.2-2.0%, nickel:0.2-3.0%, Cr:0.5-4.0%, Mo: 0.2-2.0%, B:0.001 - 0.50%, aluminum:0.001-0.50%, Ti: The adamite roll for hot rolling which consists of outer layer material which contains 0.001-0.50%, Zr:0.001-0.50%, Cu:0.001-0.50%, Mg:0.001-0.50%, and calcium:0.001-0.50%, and consists of the remainder Fe and an unescapable impurity.

(2) an outer layer - material - \*\*\*\*\* - further - mass - % - W - : - 0.2 - 3.0 - % - V - : - 0.2 - 3.0 - % - Nb - : - 0.2 - 3.0 - % - Co - : - 0.2 - 3.0 - % - \*\* - one - a sort - or - two - a sort - more than - containing - the above - (- one -) - a publication - hot rolling - \*\* - an adamite - a roll - it is .

[0005] Hereafter, this invention is explained to a detail. The microstructure of the adamite material which is this invention material consists of matrix organizations which generally performed moderate heat treatment with M3 C eutectic carbide, and became bainite or a pearlite. Among this, this invention strengthens a matrix organization by content [ minute amount Cu ], and raises abrasion resistance while it makes a minute amount contain B, aluminum, Mg, calcium, etc. and raises abrasion resistance and surface deterioration-proof nature greatly for further homogeneity and detailed-izing of M3 C eutectic carbide.

[0006]

[Embodiment of the Invention] Below, the reason for limitation of each chemical entity concerning this invention is explained.

Although C: 1.0 - 2.5%C was so effective in wear-resistant improvement that it was made to contain so much, however when it exceeded 2.5%, it made the upper limit 2.5% by the ability not attaining [ M3 C eutectic carbide's crystallizing big and rough, even if it makes a minute amount contain B, aluminum, Mg, calcium, etc. which are the description of this invention, and ] homogeneity and detailed-ization. Moreover, when it became less than 1.0%, since wear-resistant degradation took place, the minimum was made into 1.0%.

[0007] Si: Add Si for the purpose of deacidification 0.2 to 2.0%. However, the effectiveness is insufficient in it being less than 0.2%, and conversely, if it exceeds 2.0%, in order to reduce toughness, the range is made into 0.2 - 2.0%.

Mn: Add Mn for the purpose of deoxidation and a desulfurization operation 0.2 to 2.0%. However, the range is made into 0.2 - 2.0% in order to reduce toughness, if the effectiveness is insufficient in it being less than 0.2% and it exceeds 2.0%.

[0008] nickel: Add nickel 0.2 to 3.0% for reservation of improvement in hardenability, and toughness. However, since hardenability and effectiveness will be saturated with less than 0.2% if those effectiveness is weak and exceeds 3.0% on the other hand, the range is made into 0.2 - 3.0%.

Cr: Add 0.5-4.0%Cr for the increment in hardenability, the increment in a degree of hardness, the increment in tempering softening resistance, the stability of a carbide degree of hardness, etc. However, since the amount of eutectic carbide would increase too much and toughness would fall if it exceeds 4.0%, the upper limit was made into 4.0%. On the other hand, said effectiveness to add is not acquired as it is less than 0.5%. Therefore, the range is made into 0.5 - 4.0%.

[0009] Mo: Add Mo like Cr 0.2 to 2.0% for the increment in hardenability, the increment in a degree of hardness, the increment in tempering softening resistance, the stability of a carbide degree of hardness, etc. However, since the amount of eutectic carbide would increase too much and toughness would fall if it exceeds 2.0%, the upper limit was made into 2.0%. On the other hand, said effectiveness to add is not acquired as it is less than 0.2%. Therefore, the range is made into 0.2 - 2.0%.

B: 0.001 - 0.50%B is 0.001% or more, and hardenability increases and it can prevent the fall of toughness. However, if it becomes superfluous, in order for toughness to fall, it is necessary to stop to 0.50% or less.

[0010] While aluminum, Ti, Zr: 0.001 - 0.50%aluminum, and Ti and Zr generate an oxide in a molten metal, reduce the oxygen content in a molten metal and raise the soundness of a product, in order that the generated oxide may act as a crystalline nucleus, effectiveness is in detailed-ization of solidification structure. Although there was the effectiveness at 0.001%, since it became inclusion and would remain in a product when contained not much mostly, the upper limit was respectively made into 0.50%.

[0011] Cu: In order that 0.001-0.50%Cu may strengthen radical ground weave and may raise hot hardness, they are main chemical entities in B and aluminum which were mentioned above and Mg mentioned later, and calcium. however - if the effectiveness does not exist at less

than 0.001% and it exceeds 0.50% on the other hand, while abrasion resistance and crack-proof nature will fall – the front face of a roll – since description deteriorated, the upper limit was made into 0.50%.

[0012] Mg and calcium: – Mg and calcium are elements most contributed to the surface deterioration-proof nature of the roll for rolling of this invention, and wear-resistant improvement 0.001 to 0.50%. Mg and calcium are the strong elements of deoxidation or a desulfurization operation, generate the oxide of MgO or CaO, this suspends them in a molten metal, serve as a nucleus, and make detailed homogeneity crystallize M3 C eutectic carbide. Moreover, although the reason was not clear, it found out that the M3 C eutectic carbide to crystallize is detailed and equalizing according to the operation predicted to be the same phenomenon as for the graphite of spheroidal graphite cast iron to spheroidize by addition of these elements. As for the amount of Mg and calcium, the effectiveness is respectively accepted at 0.001% or more. However, if it exceeds 0.50%, while the effectiveness is saturated, since the reaction with a molten metal is intense, a lot of addition of Mg alloy or calcium alloy is dangerous in activity. Therefore, the range of Mg and calcium is respectively made into 0.001 - 0.50%.

[0013] N:1000 ppm or less N sets surface deterioration-proof nature to 1000 ppm or less for improvement. That is, by being referred to as 1000 ppm or less, the nuclear growth effectiveness over eutectic carbide is controlled, and M3 C eutectic carbide distributes to detailed and homogeneity. Thereby, surface deterioration-proof nature improves. However, if it exceeded 1000 ppm, since the effectiveness would be lost, the upper limit was set to 1000 ppm. In addition, 500 ppm or less are more desirably set to 300 ppm. As the approach of reduction, the thing which is the amount of N and for which the inside of use and a fusion furnace is made into inert gas ambient atmospheres, such as Ar, although it is few, and a raw material is dissolved is also effective in the roll waste used as the raw material of a roll, scrap material, etc.

[0014] If O:500 ppm or less O is contained in a large quantity in order that it may become nonmetallic inclusion and may reduce the cleanliness of the quality of the material, a casting crack will become easy to generate it. Therefore, it is made for the amount of reduction to be set to 500 ppm or less. In addition, it is made for 300 ppm or less to turn into 100 ppm more desirably. It is effective to make the inside of a fusion furnace into inert gas ambient atmospheres, such as Ar, and to dissolve a raw material as the approach of reduction, for example. They are so desirable that there are P and S since it mixes unescapable, and the quality of the material is weak and they are carried out from a raw material, and good to make it to P:0.2% or less and S:0.1% or less. [ little ]

[0015] Although the fundamental component of this invention material is as above-mentioned, it is good to carry out selection addition of the component of further the following suitably as other chemical entities with the size of the roll for application, the operating property of a roll demanded in addition to the chemical entity of above-mentioned this invention.

W:0.2 - 3.0%W combines with C, forms M6 C or M2 C eutectic carbide, and improves abrasion resistance while it dissolves in a matrix like Mo and strengthens a base. Although at least 0.2% or more needs to be contained for base strengthening, if it exceeds 3.0%, big and rough M6 C or M2 C eutectic carbide will be formed, and toughness will fall. Moreover, when it exceeds 3.0% with a centrifugal casting process, a stratified segregation occurs. In addition, about selection of the addition existence of W, it is good to judge suitably, for example in consideration of the abrasion resistance on an operating property, crack-proof nature, etc.

[0016] V:0.2 - 3.0%V combines with C, forms MC carbide of a high degree of hardness, and improves abrasion resistance. However, if less than 0.2% of the amount of carbide is insufficient, and abrasion resistance cannot be secured but it exceeds 3.0%, in order that MC carbide may crystallize with a primary phase, it will be made big and rough too much, and will

lead to the fall of toughness. In addition, about selection of the addition existence of V, it is good to judge suitably, for example in consideration of the abrasion resistance on an operating property, crack-proof nature, etc.

[0017] Nb: 0.2-3.0%Nb combines with C like V, forms MC carbide of a high degree of hardness, and improves abrasion resistance. However, less than 0.2% of the effectiveness is insufficient, and when it is made to contain exceeding 3.0%, in order that MC carbide may crystallize with a primary phase, it is made big and rough too much, and leads to the fall of toughness. In addition, about the selection existence of addition of Nb, it is good to judge suitably, for example in consideration of the abrasion resistance on an operating property, crack-proof nature, etc.

[0018] Co: The most dissolves in a matrix and 0.2-3.0%Co strengthens a base. Therefore, it has the operation which raises the degree of hardness and reinforcement in an elevated temperature. However, less than 0.2% of the effectiveness is insufficient, and since the effectiveness is saturated if it exceeds 3.0%, 3.0% or less is desirable also from a viewpoint of economical efficiency. In addition, about the selection existence of Co addition, it is good to judge the necessity of the addition suitably for example, in consideration of the elevated-temperature altitude on an operating property, wear multiplier reduction, etc.

[0019]

[Example] Hereafter, the example of this invention is explained with the conventional material. (Example 1) After dissolving the steel shown in Table 1 with a high frequency induction furnace, this molten metal was poured into the sand mold with a diameter [ of 100mm ], and a height of 100mm, hardening processing from 1000 degrees C and further 500-550-degree C tempering processing were performed after that, and the piece of the abrasion test between heat was created. Next, the comparative study was carried out using the heat rotation abrasion tester shown in drawing 1 . In addition, the testing machine of the disk pair disk type equipped with the rolling equipment 3 made to rotate the piece 1 of heating and a test piece 2 as shown in drawing 1 in the state of contact as a heat rotation abrasion tester, the high-frequency-induction-heating coil 4 and cooling system 5 which surround the piece 1 of heating and a test piece 2, and heat these, and the radiation thermometer 6 was used. For the test condition at that time, the best osculation stress between both disks is 2 about 25 kgf(s)/mm. Peripheral velocity (engine speed) of a test piece 2 was set to 720rpm, and performed the slip ratio between both disks at 4.5%. Moreover, temperature of the piece of heating equivalent to hot rolling material was made into 960 degrees C, 500 rotational motion of temperature of a test piece was carried out as 650 degrees C, and it measured the abrasion loss of a test piece. Then, the surface roughness of the test piece after this abrasion test was measured respectively.

[0020]

[Table 1]



表 1

| 種<br>別 | 化 学 組 成 |     |      |     |      |     |      |      |      |     |       |       |       |       | (質量%, N, O : ppm) |       |       |      |     |  |  |  |  |  | 鋼<br>來<br>従 |
|--------|---------|-----|------|-----|------|-----|------|------|------|-----|-------|-------|-------|-------|-------------------|-------|-------|------|-----|--|--|--|--|--|-------------|
|        | C       | Si  | Mn   | Ni  | Cr   | Mo  | W    | V    | Nb   | Co  | B     | Al    | Ti    | Zr    | Cu                | Mg    | Ca    | N    | O   |  |  |  |  |  |             |
| A      | 1.1     | 1.5 | 0.4  | 0.6 | 3.4  | 1.9 | —    | —    | —    | —   | 0.085 | 0.388 | 0.455 | 0.055 | 0.333             | 0.425 | 0.009 | 410  | 85  |  |  |  |  |  |             |
| B      | 1.3     | 1.9 | 1.2  | 0.8 | 0.6  | 0.3 | —    | —    | —    | —   | 0.021 | 0.008 | 0.215 | 0.008 | 0.255             | 0.007 | 0.012 | 910  | 85  |  |  |  |  |  |             |
| C      | 1.5     | 0.3 | 1.3  | 2.1 | 1.9  | 1.5 | —    | —    | —    | —   | 0.355 | 0.488 | 0.047 | 0.488 | 0.028             | 0.485 | 0.499 | 240  | 35  |  |  |  |  |  |             |
| D      | 1.8     | 1.7 | 0.25 | 1.1 | 2.2  | 1.7 | —    | —    | —    | —   | 0.004 | 0.015 | 0.005 | 0.045 | 0.004             | 0.025 | 0.049 | 280  | 80  |  |  |  |  |  |             |
| E      | 2.2     | 0.5 | 1.9  | 2.8 | 3.9  | 0.5 | —    | —    | —    | —   | 0.495 | 0.009 | 0.495 | 0.003 | 0.048             | 0.005 | 0.088 | 860  | 83  |  |  |  |  |  |             |
| F      | 2.45    | 0.4 | 1.1  | 1.5 | 2.2  | 1.6 | —    | —    | —    | —   | 0.012 | 0.041 | 0.082 | 0.445 | 0.244             | 0.047 | 0.004 | 430  | 35  |  |  |  |  |  |             |
| G      | 1.7     | 1.2 | 1.5  | 1.5 | 3.9  | 1.5 | 0.3  | —    | —    | —   | 0.456 | 0.005 | 0.003 | 0.485 | 0.485             | 0.005 | 0.047 | 220  | 86  |  |  |  |  |  |             |
| H      | 1.9     | 1.8 | 0.5  | 2.4 | 2.2  | 1.4 | 2.8  | —    | —    | —   | 0.004 | 0.333 | 0.455 | 0.005 | 0.003             | 0.485 | 0.003 | 690  | 77  |  |  |  |  |  |             |
| I      | 1.6     | 0.9 | 1.3  | 2.3 | 2.1  | 1.5 | —    | 2.2  | —    | —   | 0.004 | 0.465 | 0.003 | 0.255 | 0.355             | 0.015 | 0.004 | 190  | 65  |  |  |  |  |  |             |
| J      | 1.8     | 1.2 | 0.3  | 1.5 | 2.4  | 1.8 | 1.5  | 1.9  | —    | —   | 0.425 | 0.033 | 0.045 | 0.005 | 0.008             | 0.005 | 0.021 | 430  | 35  |  |  |  |  |  |             |
| K      | 1.7     | 0.9 | 1.3  | 2.5 | 2.5  | 1.2 | —    | —    | 1.5  | —   | 0.444 | 0.008 | 0.135 | 0.485 | 0.254             | 0.004 | 0.027 | 240  | 70  |  |  |  |  |  |             |
| L      | 1.9     | 0.8 | 1.5  | 2.1 | 2.4  | 1.7 | 1.8  | 1.5  | 1.8  | —   | 0.004 | 0.325 | 0.008 | 0.005 | 0.003             | 0.485 | 0.005 | 620  | 50  |  |  |  |  |  |             |
| M      | 1.5     | 1.1 | 1.3  | 2.7 | 2.4  | 1.6 | —    | —    | —    | 1.5 | 0.006 | 0.009 | 0.125 | 0.355 | 0.488             | 0.004 | 0.005 | 200  | 50  |  |  |  |  |  |             |
| N      | 1.9     | 1.3 | 0.9  | 2.2 | 2.1  | 1.1 | 1.5  | 1.8  | 1.6  | 1.6 | 0.485 | 0.255 | 0.012 | 0.043 | 0.005             | 0.125 | 0.033 | 510  | 35  |  |  |  |  |  |             |
| O      | 1.7     | 0.8 | 0.8  | 0.6 | 0.25 | 1.3 | 0.55 | 0.15 | —    | —   | —     | —     | 0.28  | —     | —                 | —     | —     | 1150 | 150 |  |  |  |  |  |             |
| P      | 1.9     | 0.7 | 1.2  | 2.4 | 0.21 | 0.8 | 0.35 | 0.22 | 0.45 | —   | —     | —     | —     | 0.18  | —                 | —     | —     | 1200 | 130 |  |  |  |  |  |             |
| Q      | 2.1     | 0.8 | 0.9  | 2.2 | 0.23 | 1.1 | —    | 0.54 | 0.52 | —   | —     | —     | 1.18  | 0.45  | —                 | —     | —     | 1310 | 210 |  |  |  |  |  |             |
| R      | 1.6     | 0.7 | 0.8  | 1.8 | 0.18 | 0.7 | 0.77 | 0.45 | 0.22 | —   | —     | —     | 0.22  | —     | —                 | —     | —     | 1050 | 125 |  |  |  |  |  |             |

[0021] Drawing 2 is drawing showing the measurement result of the abrasion loss by the heat rotation abrasion test of the O-R material which is the example A-N material of this invention, and the conventional example. Moreover, drawing 3 is drawing showing the measurement result of the surface roughness of the test piece after the heat rotation abrasion test of this invention material and the conventional material. As for this invention material A-N material, as compared with conventional material O-R, all have few those abrasion losses, and the surface roughness used as the index of evaluation of surface deterioration-proof nature is also small so that clearly from this drawing 2 and drawing 3. The result which became clear [ this invention material's fully doing so the operation and effectiveness of abrasion resistance and surface deterioration-proof nature made into the purpose, when it applies to an actual reduction roll ], then was applied to the actual reduction roll by the result of various kinds of

above trials is explained.

[0022] (Example 2) The Fe-Si-Mg alloy was added to the outer layer molten metal dissolved using the low frequency induction furnace in the after [ tapping ] ladle, and the molten metal of the chemical composition of this invention shown in Table 2 was poured into it into rotation mold with a bore [ of 800mm ] included in the level-type centrifugal casting machine, and a die length of 2000mm. Next, finish-machining was performed, after having cooled this roll, performing rough-machining processing after dismantling from centrifugal-pressure-casting mold and carrying out several tempering processings at 1000-degree C hardening and 500-550 degrees C. Then, the ultrasonic crack inspect was performed and it checked that it was a healthy roll without a defect. Then, the sleeve roll for this rolling was created separately after that. For example, it attached in steel roll axes and the roll for rolling of one apparatus was presented after \*\*\*\*\* at actual die steel rolling. Consequently, compared with the conventional sleeve roll for rolling, the material unit of a roll improved about 20% by improvement in abrasion resistance and surface deterioration-proof nature, and it checked that the effectiveness of this invention material was great.

[0023]

[Table 2]

表 2

|      | 化 学 组 成 |     |     |     |     |     |   |   |    |    |       | (質量%、N, O : ppm) |       |       |       |       |       |     |    |
|------|---------|-----|-----|-----|-----|-----|---|---|----|----|-------|------------------|-------|-------|-------|-------|-------|-----|----|
|      | C       | Si  | Mn  | Ni  | Cr  | Mo  | W | V | Nb | Co | B     | Al               | Ti    | Zr    | Cu    | Mg    | Ca    | N   | O  |
| 化学成分 | 1.7     | 1.1 | 1.2 | 1.5 | 3.3 | 1.1 | — | — | —  | —  | 0.015 | 0.021            | 0.008 | 0.015 | 0.045 | 0.038 | 0.021 | 500 | 95 |

[0024] In addition, although the roll for rolling manufactured in the aforementioned example 2 is a sleeve roll of a monolayer manufactured with the centrifugal casting process As application of this invention, it is not what is limited to this. As the application It burns and inserts in, and at when [ of a shaft and a sleeve / the time when reinforcement is large when the reinforcement of sleeve rolls, such as the adult time, is required of rolling load ] etc., as aforementioned, molten metals, such as graphitic steel, are first poured in after forming the outer layer of this invention material with a centrifugal casting process, and it is good also as a compound sleeve roll.

[0025] Moreover, in for steel plate rolling, as another example of application, it is applicable also not only as a sleeve roll but a solid roll. For example, after pouring in the molten metal which serves as an interlayer after pouring into a centrifugal casting machine the molten metal

for outer layers which consists of a chemical entity of this invention like the publication to JP,5-311316,A after passing through the proper latency time, and passing through the still more proper latency time, rotation of a centrifugal casting machine is stopped and it can apply also like the hollow roll of the three-tiered structure which divides molten metals, such as ductile cast iron or graphitic steel, into abundance, pours them in, and manufactures them as a charge of inner layer material for core materials after that. As other examples, it is good also as a solid roll of the two-layer structure where an interlayer is not prepared, in the aforementioned example. Furthermore, in the case of the application of the breakdown roll of shape steel rolling etc., it is good as another example to pour the molten metal of the chemical entity of this invention into the standing mold of a vertical type, and to form the roll of one apparatus.

[0026]

[Effect of the Invention] As stated above, the roll for rolling of this invention While making a minute amount contain B, aluminum, Mg, calcium, etc. and raising abrasion resistance and surface deterioration-proof nature greatly for further homogeneity and detailed-izing of M3 C eutectic carbide A matrix organization is strengthened by content [ minute amount Cu ], it is for raising abrasion resistance, the large improvement in surface deterioration-proof nature and abrasion resistance is attained, reduction roll reinforcement is attained, and large improvement in a roll material unit can be performed. Moreover, there is effectiveness which contributes also to upgrading of the flat rolled product by improvement in the roll engine performance sharply.

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[Translation done.]

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**TECHNICAL FIELD**

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[Field of the Invention] This invention is used for hot rolling of the die steel of steel, sheet metal, a thick plate, etc., and relates to the adamite roll for hot rolling which was especially excellent in abrasion resistance and surface deterioration-proof nature.

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**PRIOR ART**

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[Description of the Prior Art] In recent years, in the hot rolling fields, such as steel, for example, die steel, sheet metal, and a thick plate, the demand of upgrading of a flat rolled product is high, and high abrasion resistance and surface deterioration-proof nature are called for also from the roll for rolling. It is indicated by JP,62-18241,B as outer layer material of the adamite roll for rolling corresponding to these demands. To the adamite material which is low alloy high carbon steel-casting material known from the former, these technical contents tend to add Ti, Zr, etc. in a minute amount, tend to make homogeneity and detailed the M3 C eutectic carbide which consists in the perimeter of a matrix in a matrix, and, as a result, tend to raise the abrasion resistance of a reduction roll, and surface deterioration-proof nature.

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**EFFECT OF THE INVENTION**

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[Effect of the Invention] As stated above, the roll for rolling of this invention While making a minute amount contain B, aluminum, Mg, calcium, etc. and raising abrasion resistance and surface deterioration-proof nature greatly for further homogeneity and detailed-izing of M3 C eutectic carbide A matrix organization is strengthened by content [ minute amount Cu ], it is for raising abrasion resistance, the large improvement in surface deterioration-proof nature and abrasion resistance is attained, reduction roll reinforcement is attained, and large improvement in a roll material unit can be performed. Moreover, there is effectiveness which contributes also to upgrading of the flat rolled product by improvement in the roll engine performance sharply.

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**TECHNICAL PROBLEM**

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[Problem(s) to be Solved by the Invention] however, with said conventional roll for rolling By the homogeneity and detailed-ization of the M3 C eutectic carbide which consists in the perimeter of a matrix Although the abrasion resistance of a reduction roll and surface deterioration-proof nature improve considerably, in order to correspond to the present severe rolling operation, i.e., a high speed, a heavy load, a large draft, etc. In the point of the abrasion resistance of a reduction roll, and surface deterioration-proof nature, the expectation by users, such as improvement in a roll material unit and simplification of the maintenance service of a roll, is still great not sufficient thing but the result. This invention aims at what the M3 C eutectic carbide which consists in the perimeter of a matrix tends to be made to make it homogeneity and detailed further, consequently it is going to raise sharply the abrasion resistance of a reduction roll, and surface deterioration-proof nature for in view of the above background.

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MEANS

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[Means for Solving the Problem] The place which this invention is what solved the problem mentioned above, and is made into the summary of the invention (1) By mass %, C:1.0 - 2.5%, Si:0.2-2.0%, Mn: 0.2-2.0%, nickel:0.2-3.0%, Cr:0.5-4.0%, Mo: 0.2-2.0%, B:0.001 - 0.50%, aluminum:0.001-0.50%, Ti: The adamite roll for hot rolling which consists of outer layer material which contains 0.001-0.50%, Zr:0.001-0.50%, Cu:0.001-0.50%, Mg:0.001-0.50%, and calcium:0.001-0.50%, and consists of the remainder Fe and an unescapable impurity.

(2) an outer layer - material - \*\*\*\*\* - further - mass - % - W - : - 0.2 - 3.0 - % - V - : - 0.2 - 3.0 - % - Nb - : - 0.2 - 3.0 - % - Co - : - 0.2 - 3.0 - % - \*\* - one - a sort - or - two - a sort - more than - containing - the above - (- one -) - a publication - hot rolling - \*\* - an adamite - a roll - it is .

[0005] Hereafter, this invention is explained to a detail. The microstructure of the adamite material which is this invention material consists of matrix organizations which generally performed moderate heat treatment with M3 C eutectic carbide, and became bainite or a pearlite. Among this, this invention strengthens a matrix organization by content [ minute amount Cu ], and raises abrasion resistance while it makes a minute amount contain B, aluminum, Mg, calcium, etc. and raises abrasion resistance and surface deterioration-proof nature greatly for further homogeneity and detailed-izing of M3 C eutectic carbide.

[0006]

[Embodiment of the Invention] Below, the reason for limitation of each chemical entity concerning this invention is explained.

Although C:1.0 - 2.5%C was so effective in wear-resistant improvement that it was made to contain so much, however when it exceeded 2.5%, it made the upper limit 2.5% by the ability not attaining [ M3 C eutectic carbide's crystallizing big and rough, even if it makes a minute amount contain B, aluminium, Mg, calcium, etc. which are the description of this invention, and ] homogeneity and detailed-ization. Moreover, when it became less than 1.0%, since wear-resistant degradation took place, the minimum was made into 1.0%.

[0007] Si: Add Si for the purpose of deacidification 0.2 to 2.0%. However, the effectiveness is insufficient in it being less than 0.2%, and conversely, if it exceeds 2.0%, in order to reduce toughness, the range is made into 0.2 - 2.0%.

Mn: Add Mn for the purpose of deoxidation and a desulfurization operation 0.2 to 2.0%. However, the range is made into 0.2 - 2.0% in order to reduce toughness, if the effectiveness is insufficient in it being less than 0.2% and it exceeds 2.0%.

[0008] nickel: Add nickel 0.2 to 3.0% for reservation of improvement in hardenability, and toughness. However, since hardenability and effectiveness will be saturated with less than 0.2% if those effectiveness is weak and exceeds 3.0% on the other hand, the range is made into 0.2 - 3.0%.

Cr: Add 0.5-4.0%Cr for the increment in hardenability, the increment in a degree of hardness, the increment in tempering softening resistance, the stability of a carbide degree of hardness,

etc. However, since the amount of eutectic carbide would increase too much and toughness would fall if it exceeds 4.0%, the upper limit was made into 4.0%. On the other hand, said effectiveness to add is not acquired as it is less than 0.5%. Therefore, the range is made into 0.5 - 4.0%.

[0009] Mo: Add Mo like Cr 0.2 to 2.0% for the increment in hardenability, the increment in a degree of hardness, the increment in tempering softening resistance, the stability of a carbide degree of hardness, etc. However, since the amount of eutectic carbide would increase too much and toughness would fall if it exceeds 2.0%, the upper limit was made into 2.0%. On the other hand, said effectiveness to add is not acquired as it is less than 0.2%. Therefore, the range is made into 0.2 - 2.0%.

B: 0.001 - 0.50% B is 0.001% or more, and hardenability increases and it can prevent the fall of toughness. However, if it becomes superfluous, in order for toughness to fall, it is necessary to stop to 0.50% or less.

[0010] While aluminum, Ti, Zr: 0.001 - 0.50% aluminum, and Ti and Zr generate an oxide in a molten metal, reduce the oxygen content in a molten metal and raise the soundness of a product, in order that the generated oxide may act as a crystalline nucleus, effectiveness is in detailed-ization of solidification structure. Although there was the effectiveness at 0.001%, since it became inclusion and would remain in a product when contained not much mostly, the upper limit was respectively made into 0.50%.

[0011] Cu: In order that 0.001-0.50% Cu may strengthen radical ground weave and may raise hot hardness, they are main chemical entities in B and aluminum which were mentioned above and Mg mentioned later, and calcium. however – if the effectiveness does not exist at less than 0.001% and it exceeds 0.50% on the other hand, while abrasion resistance and crack-proof nature will fall – the front face of a roll – since description deteriorated, the upper limit was made into 0.50%.

[0012] Mg and calcium: – Mg and calcium are elements most contributed to the surface deterioration-proof nature of the roll for rolling of this invention, and wear-resistant improvement 0.001 to 0.50%. Mg and calcium are the strong elements of deoxidation or a desulfurization operation, generate the oxide of MgO or CaO, this suspends them in a molten metal, serve as a nucleus, and make detailed homogeneity crystallize M3 C eutectic carbide. Moreover, although the reason was not clear, it found out that the M3 C eutectic carbide to crystallize is detailed and equalizing according to the operation predicted to be the same phenomenon as for the graphite of spheroidal graphite cast iron to spheroidize by addition of these elements. As for the amount of Mg and calcium, the effectiveness is respectively accepted at 0.001% or more. However, if it exceeds 0.50%, while the effectiveness is saturated, since the reaction with a molten metal is intense, a lot of addition of Mg alloy or calcium alloy is dangerous in activity. Therefore, the range of Mg and calcium is respectively made into 0.001 - 0.50%.

[0013] N: 1000 ppm or less N sets surface deterioration-proof nature to 1000 ppm or less for improvement. That is, by being referred to as 1000 ppm or less, the nuclear growth effectiveness over eutectic carbide is controlled, and M3 C eutectic carbide distributes to detailed and homogeneity. Thereby, surface deterioration-proof nature improves. However, if it exceeded 1000 ppm, since the effectiveness would be lost, the upper limit was set to 1000 ppm. In addition, 500 ppm or less are more desirably set to 300 ppm. As the approach of reduction, the thing which is the amount of N and for which the inside of use and a fusion furnace is made into inert gas ambient atmospheres, such as Ar, although it is few, and a raw material is dissolved is also effective in the roll waste used as the raw material of a roll, scrap material, etc.

[0014] If O: 500 ppm or less O is contained in a large quantity in order that it may become nonmetallic inclusion and may reduce the cleanliness of the quality of the material, a casting

crack will become easy to generate it. Therefore, it is made for the amount of reduction to be set to 500 ppm or less. In addition, it is made for 300 ppm or less to turn into 100 ppm more desirably. It is effective to make the inside of a fusion furnace into inert gas ambient atmospheres, such as Ar, and to dissolve a raw material as the approach of reduction, for example. They are so desirable that there are P and S since it mixes unescapable, and the quality of the material is weak and they are carried out from a raw material, and good to make it to P:0.2% or less and S:0.1% or less. [ little ]

[0015] Although the fundamental component of this invention material is as above-mentioned, it is good to carry out selection addition of the component of further the following suitably as other chemical entities with the size of the roll for application, the operating property of a roll demanded in addition to the chemical entity of above-mentioned this invention.

W:0.2 - 3.0%W combines with C, forms M<sub>6</sub>C or M<sub>2</sub>C eutectic carbide, and improves abrasion resistance while it dissolves in a matrix like Mo and strengthens a base. Although at least 0.2% or more needs to be contained for base strengthening, if it exceeds 3.0%, big and rough M<sub>6</sub>C or M<sub>2</sub>C eutectic carbide will be formed, and toughness will fall. Moreover, when it exceeds 3.0% with a centrifugal casting process, a stratified segregation occurs. In addition, about selection of the addition existence of W, it is good to judge suitably, for example in consideration of the abrasion resistance on an operating property, crack-proof nature, etc.

[0016] V:0.2 - 3.0%V combines with C, forms MC carbide of a high degree of hardness, and improves abrasion resistance. However, if less than 0.2% of the amount of carbide is insufficient, and abrasion resistance cannot be secured but it exceeds 3.0%, in order that MC carbide may crystallize with a primary phase, it will be made big and rough too much, and will lead to the fall of toughness. In addition, about selection of the addition existence of V, it is good to judge suitably, for example in consideration of the abrasion resistance on an operating property, crack-proof nature, etc.

[0017] Nb: 0.2-3.0%Nb combines with C like V, forms MC carbide of a high degree of hardness, and improves abrasion resistance. However, less than 0.2% of the effectiveness is insufficient, and when it is made to contain exceeding 3.0%, in order that MC carbide may crystallize with a primary phase, it is made big and rough too much, and leads to the fall of toughness. In addition, about the selection existence of addition of Nb, it is good to judge suitably, for example in consideration of the abrasion resistance on an operating property, crack-proof nature, etc.

[0018] Co: The most dissolves in a matrix and 0.2-3.0%Co strengthens a base. Therefore, it has the operation which raises the degree of hardness and reinforcement in an elevated temperature. However, less than 0.2% of the effectiveness is insufficient, and since the effectiveness is saturated if it exceeds 3.0%, 3.0% or less is desirable also from a viewpoint of economical efficiency. In addition, about the selection existence of Co addition, it is good to judge the necessity of the addition suitably for example, in consideration of the elevated-temperature altitude on an operating property, wear multiplier reduction, etc.

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**EXAMPLE**

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[Example] Hereafter, the example of this invention is explained with the conventional material. (Example 1) After dissolving the steel shown in Table 1 with a high frequency induction furnace, this molten metal was poured into the sand mold with a diameter [ of 100mm ], and a height of 100mm, hardening processing from 1000 degrees C and further 500-550-degree C tempering processing were performed after that, and the piece of the abrasion test between heat was created. Next, the comparative study was carried out using the heat rotation abrasion tester shown in drawing 1 . In addition, the testing machine of the disk pair disk type equipped with the rolling equipment 3 made to rotate the piece 1 of heating and a test piece 2 as shown in drawing 1 in the state of contact as a heat rotation abrasion tester, the high-frequency-induction-heating coil 4 and cooling system 5 which surround the piece 1 of heating and a test piece 2, and heat these, and the radiation thermometer 6 was used. For the test condition at that time, the best osculation stress between both disks is 2 about 25 kgf(s)/mm. Peripheral velocity (engine speed) of a test piece 2 was set to 720rpm, and performed the slip ratio between both disks at 4.5%. Moreover, temperature of the piece of heating equivalent to hot rolling material was made into 960 degrees C, 500 rotational motion of temperature of a test piece was carried out as 650 degrees C, and it measured the abrasion loss of a test piece. Then, the surface roughness of the test piece after this abrasion test was measured respectively.

[0020]

[Table 1]

表 1

| 種別 | 化 学 組 成 |     |      |     |      |     |      |      |      |     |       |       |       |       | (質量%, N, O : ppm) |       |       |      |     |  |  |  |  |  | 本 発 明 例 | 従 来 例 | 鋼 |
|----|---------|-----|------|-----|------|-----|------|------|------|-----|-------|-------|-------|-------|-------------------|-------|-------|------|-----|--|--|--|--|--|---------|-------|---|
|    | C       | Si  | Mn   | Ni  | Cr   | Mo  | W    | V    | Nb   | Co  | B     | Al    | Ti    | Zr    | Cu                | Mg    | Ca    | N    | O   |  |  |  |  |  |         |       |   |
| A  | 1.1     | 1.5 | 0.4  | 0.6 | 3.4  | 1.9 | —    | —    | —    | —   | 0.085 | 0.398 | 0.455 | 0.055 | 0.333             | 0.425 | 0.009 | 410  | 85  |  |  |  |  |  |         |       |   |
| B  | 1.3     | 1.9 | 1.2  | 0.8 | 0.6  | 0.3 | —    | —    | —    | —   | 0.021 | 0.008 | 0.215 | 0.008 | 0.255             | 0.007 | 0.012 | 910  | 85  |  |  |  |  |  |         |       |   |
| C  | 1.5     | 0.3 | 1.3  | 2.1 | 1.9  | 1.5 | —    | —    | —    | —   | 0.355 | 0.488 | 0.047 | 0.488 | 0.028             | 0.485 | 0.499 | 240  | 35  |  |  |  |  |  |         |       |   |
| D  | 1.8     | 1.7 | 0.25 | 1.1 | 2.2  | 1.7 | —    | —    | —    | —   | 0.004 | 0.015 | 0.005 | 0.045 | 0.004             | 0.025 | 0.049 | 280  | 80  |  |  |  |  |  |         |       |   |
| E  | 2.2     | 0.5 | 1.9  | 2.8 | 3.9  | 0.5 | —    | —    | —    | —   | 0.495 | 0.009 | 0.495 | 0.003 | 0.048             | 0.005 | 0.088 | 880  | 93  |  |  |  |  |  |         |       |   |
| F  | 2.45    | 0.4 | 1.1  | 1.5 | 2.2  | 1.6 | —    | —    | —    | —   | 0.012 | 0.041 | 0.092 | 0.445 | 0.244             | 0.047 | 0.004 | 430  | 35  |  |  |  |  |  |         |       |   |
| G  | 1.7     | 1.2 | 1.5  | 1.5 | 3.9  | 1.5 | 0.3  | —    | —    | —   | 0.456 | 0.005 | 0.003 | 0.485 | 0.485             | 0.005 | 0.047 | 220  | 86  |  |  |  |  |  |         |       |   |
| H  | 1.9     | 1.8 | 0.5  | 2.4 | 2.2  | 1.4 | 2.8  | —    | —    | —   | 0.004 | 0.333 | 0.455 | 0.005 | 0.003             | 0.485 | 0.003 | 530  | 77  |  |  |  |  |  |         |       |   |
| I  | 1.6     | 0.9 | 1.3  | 2.3 | 2.1  | 1.5 | —    | 2.2  | —    | —   | 0.004 | 0.485 | 0.003 | 0.255 | 0.355             | 0.015 | 0.004 | 190  | 65  |  |  |  |  |  |         |       |   |
| J  | 1.8     | 1.2 | 0.3  | 1.5 | 2.4  | 1.8 | 1.5  | 1.9  | —    | —   | 0.425 | 0.033 | 0.045 | 0.005 | 0.008             | 0.005 | 0.021 | 490  | 35  |  |  |  |  |  |         |       |   |
| K  | 1.7     | 0.9 | 1.3  | 2.5 | 2.5  | 1.2 | —    | —    | 1.5  | —   | 0.444 | 0.008 | 0.135 | 0.485 | 0.254             | 0.004 | 0.027 | 240  | 70  |  |  |  |  |  |         |       |   |
| L  | 1.9     | 0.8 | 1.5  | 2.1 | 2.4  | 1.7 | 1.8  | 1.5  | 1.8  | —   | 0.004 | 0.325 | 0.008 | 0.005 | 0.003             | 0.485 | 0.005 | 620  | 50  |  |  |  |  |  |         |       |   |
| M  | 1.5     | 1.1 | 1.3  | 2.7 | 2.4  | 1.6 | —    | —    | —    | 1.5 | 0.006 | 0.009 | 0.125 | 0.355 | 0.488             | 0.004 | 0.005 | 200  | 50  |  |  |  |  |  |         |       |   |
| N  | 1.9     | 1.3 | 0.9  | 2.2 | 2.1  | 1.1 | 1.5  | 1.8  | 1.6  | 1.6 | 0.485 | 0.255 | 0.012 | 0.043 | 0.005             | 0.125 | 0.033 | 510  | 35  |  |  |  |  |  |         |       |   |
| O  | 1.7     | 0.8 | 0.8  | 0.6 | 0.25 | 1.3 | 0.55 | 0.15 | —    | —   | —     | —     | 0.28  | —     | —                 | —     | —     | 1150 | 150 |  |  |  |  |  |         |       |   |
| P  | 1.9     | 0.7 | 1.2  | 2.4 | 0.21 | 0.8 | 0.35 | 0.22 | 0.45 | —   | —     | —     | —     | 0.18  | —                 | —     | —     | 1200 | 130 |  |  |  |  |  |         |       |   |
| Q  | 2.1     | 0.8 | 0.9  | 2.2 | 0.23 | 1.1 | —    | 0.54 | 0.52 | —   | —     | —     | 1.18  | 0.45  | —                 | —     | —     | 1310 | 210 |  |  |  |  |  |         |       |   |
| R  | 1.6     | 0.7 | 0.8  | 1.8 | 0.18 | 0.7 | 0.77 | 0.45 | 0.22 | —   | —     | —     | 0.22  | —     | —                 | —     | —     | 1050 | 125 |  |  |  |  |  |         |       |   |

[0021] Drawing 2 is drawing showing the measurement result of the abrasion loss by the heat rotation abrasion test of the O-R material which is the example A-N material of this invention, and the conventional example. Moreover, drawing 3 is drawing showing the measurement result of the surface roughness of the test piece after the heat rotation abrasion test of this invention material and the conventional material. As for this invention material A-N material, as compared with conventional material O-R, all have few those abrasion losses, and the surface roughness used as the index of evaluation of surface deterioration-proof nature is also small so that clearly from this drawing 2 and drawing 3. The result which became clear [ this invention material's fully doing so the operation and effectiveness of abrasion resistance and surface deterioration-proof nature made into the purpose, when it applies to an actual reduction roll ], then was applied to the actual reduction roll by the result of various kinds of

above trials is explained.

[0022] (Example 2) The Fe-Si-Mg alloy was added to the outer layer molten metal dissolved using the low frequency induction furnace in the after [ tapping ] ladle, and the molten metal of the chemical composition of this invention shown in Table 2 was poured into it into rotation mold with a bore [ of 800mm ] included in the level-type centrifugal casting machine, and a die length of 2000mm. Next, finish-machining was performed, after having cooled this roll, performing rough-machining processing after dismantling from centrifugal-pressure-casting mold and carrying out several tempering processings at 1000-degree C hardening and 500-550 degrees C. Then, the ultrasonic crack inspect was performed and it checked that it was a healthy roll without a defect. Then, the sleeve roll for this rolling was created separately after that. For example, it attached in steel roll axes and the roll for rolling of one apparatus was presented after \*\*\*\*\* at actual die steel rolling. Consequently, compared with the conventional sleeve roll for rolling, the material unit of a roll improved about 20% by improvement in abrasion resistance and surface deterioration-proof nature, and it checked that the effectiveness of this invention material was great.

[0023]

[Table 2]

表 2

|      | 化 学 组 成 |     |     |     |     |     |   |   |    |    |       | (質量%, N, O : ppm) |       |       |       |       |       |     |    |
|------|---------|-----|-----|-----|-----|-----|---|---|----|----|-------|-------------------|-------|-------|-------|-------|-------|-----|----|
|      | C       | Si  | Mn  | Ni  | Cr  | Mo  | W | V | Nb | Co | B     | Al                | Ti    | Zr    | Cu    | Mg    | Ca    | N   | O  |
| 化学成分 | 1.7     | 1.1 | 1.2 | 1.5 | 3.3 | 1.1 | — | — | —  | —  | 0.015 | 0.021             | 0.008 | 0.015 | 0.045 | 0.038 | 0.021 | 500 | 95 |

[0024] In addition, although the roll for rolling manufactured in the aforementioned example 2 is a sleeve roll of a monolayer manufactured with the centrifugal casting process As application of this invention, it is not what is limited to this. As the application It burns and inserts in, and at when [ of a shaft and a sleeve / the time when reinforcement is large when the reinforcement of sleeve rolls, such as the adult time, is required of rolling load ] etc., as aforementioned, molten metals, such as graphitic steel, are first poured in after forming the outer layer of this invention material with a centrifugal casting process, and it is good also as a compound sleeve roll.

[0025] Moreover, in for steel plate rolling, as another example of application, it is applicable also not only as a sleeve roll but a solid roll. For example, after pouring in the molten metal which serves as an interlayer after pouring into a centrifugal casting machine the molten metal

for outer layers which consists of a chemical entity of this invention like the publication to JP,5-311316,A after passing through the proper latency time, and passing through the still more proper latency time, rotation of a centrifugal casting machine is stopped and it can apply also like the hollow roll of the three-tiered structure which divides molten metals, such as ductile cast iron or graphitic steel, into abundance, pours them in, and manufactures them as a charge of inner layer material for core materials after that. As other examples, it is good also as a solid roll of the two-layer structure where an interlayer is not prepared, in the aforementioned example. Furthermore, in the case of the application of the breakdown roll of shape steel rolling etc., it is good as another example to pour the molten metal of the chemical entity of this invention into the standing mold of a vertical type, and to form the roll of one apparatus.

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**DESCRIPTION OF DRAWINGS**

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[Brief Description of the Drawings]

[Drawing 1] It is the explanatory view showing the outline configuration of a heat rotation abrasion tester.

[Drawing 2] It is drawing showing the abrasion loss by the rotation abrasion test of this invention material and the conventional material.

[Drawing 3] It is drawing showing the surface roughness after the rotation abrasion test of this invention material and the conventional material.

[Description of Notations]

- 1 Piece of Heating
- 2 Test Piece
- 3 Rolling Equipment
- 4 High-frequency-Induction-Heating Coil
- 5 Cooling System
- 6 Radiation Thermometer

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[Translation done.]

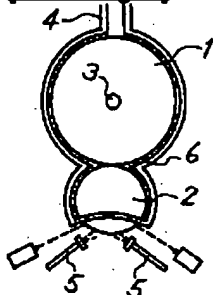
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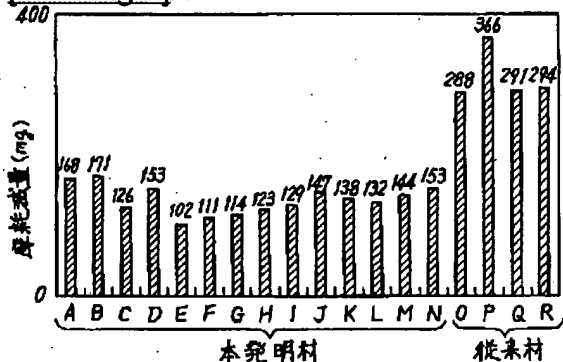
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## DRAWINGS

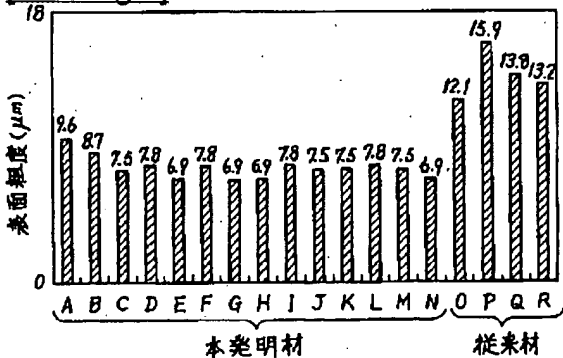
[Drawing 1]



[Drawing 2]



[Drawing 3]



[Translation done.]